Role of Vrana Shodhana and Vrana Ropana in Tissue Repair: A Review of Classical and Modern Concepts

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***Abstract*- The management of wounds has been a central focus of surgery since ancient times, and Ayurveda offers one of the most detailed and rational systems of wound care, particularly through the twin principles of Vrana Shodhana (wound purification) and Vrana Ropana (wound healing and tissue regeneration). These principles extend beyond local wound treatment to include systemic correction of *Dosha* imbalances, emphasizing a holistic approach. Modern biomedical science describes wound healing as a dynamic, multi-phase process involving hemostasis, inflammation, proliferation, and remodeling. Remarkably, the Ayurvedic concepts of *Shodhana* and *Ropana* correspond closely to these biological phases. This review critically examines classical teachings from the *Sushruta Samhita*, *Charaka Samhita*, and *Ashtanga Hridaya* and correlates them with contemporary understanding of tissue repair, including molecular mechanisms such as cytokine modulation, angiogenesis, and extracellular matrix remodeling. Key *Shodhana* dravyas (e.g., *Nimba*, *Triphala*, *Haridra*) exhibit antimicrobial, anti-inflammatory, and antioxidant actions, while *Ropana* agents (e.g., *Jatyadi Taila*, *Madhu*, *Yashtimadhu*) promote fibroblast proliferation, collagen synthesis, and re-epithelialization. The sequential logic of cleansing before healing aligns with modern wound bed preparation protocols. Clinical relevance is particularly strong for chronic non-healing wounds, diabetic foot ulcers, and infected wounds, where integration of these Ayurvedic principles can improve outcomes. Thus, *Vrana Shodhana* and *Vrana Ropana* offer a scientifically valid, stage-specific, and clinically applicable framework that complements modern wound care.**

Keywords: Vrana, Vrana Shodhana, Vrana Ropana, wound healing, tissue repair, Ayurveda, inflammation, granulation

I. INTRODUCTION

Vrana (wound) represents one of the most comprehensively described pathological entities in the *Brihat Trayi* (the three great classics of Ayurveda), particularly in the *Sushruta Samhita*, which is widely regarded as the foundational text of *Shalya Tantra* (surgery) [1]. A *Vrana* is defined as a disruption of anatomical integrity and physiological continuity of body tissues (*twak*, *mamsa*, *sira*, *snayu*, *asthi*, and *sandhi*), often accompanied by cardinal features such as pain (*shoola*), discharge (*srava*), swelling (*shopha*), and functional impairment [1,2].

The classical approach to wound management is fundamentally based on a two-step sequential principle:

"शोधनं रोपणं चैव व्रणानां परिकीर्तितम्" (Purification and healing are the two key actions described for wounds) [1].

This aphorism underscores that effective wound care cannot be achieved without first cleansing the wound and then promoting tissue regeneration. Without adequate *Shodhana*, *Ropana* is compromised; without *Ropana*, anatomical and functional restoration remains incomplete [3].

From a modern biomedical perspective, wound healing is a highly regulated, multi-phasic cascade involving:

- Hemostasis (immediate vasoconstriction, platelet aggregation, clot formation)
- Inflammation (neutrophil and macrophage infiltration, cytokine and chemokine signaling)
- Proliferation (angiogenesis, fibroblast proliferation, granulation tissue formation, re-epithelialization)
- Remodeling (collagen cross-linking, extracellular matrix reorganization, scar maturation) [6,7].

Ayurveda conceptualizes these processes through the dual frameworks of Shodhana and Ropana. *Shodhana* corresponds to the removal of vitiated *Doshas*, necrotic tissue (*puyasrava*), and microbial biofilms – essentially preparing the wound bed. *Ropana* then stimulates the

formation of healthy granulation tissue (*mamsa rohana*), angiogenesis (*sira prarohana*), and epithelial coverage [2,3].

What makes Ayurvedic wound care distinctive is its integrative, stage-specific, and holistic nature. It does not treat the wound in isolation but considers the patient's *Dosha* constitution, metabolic state (*agni*), nutritional status (*ahara*), and psychological factors (*manas*). Furthermore, it employs a wide range of topical formulations (*taila*, *ghrita*, *lepa*, *kalka*) and systemic interventions (*shamana*, *shodhana*, *rasayana*) that have recently garnered scientific interest for their antimicrobial, anti-inflammatory, antioxidant, and tissue-regenerative properties [8,9].

Despite advances in modern wound care – such as growth factor therapy, bioengineered skin substitutes, and negative pressure wound therapy – chronic non-healing wounds (e.g., diabetic foot ulcers, pressure sores, venous ulcers) remain a significant clinical challenge, leading to prolonged morbidity, high healthcare costs, and reduced quality of life [6,7]. In this context, revisiting and integrating Ayurvedic principles of *Shodhana* and *Ropana* offers a promising complementary approach.

This review aims to:

1. Provide an in-depth classical exposition of *Vrana*, *Shodhana*, and *Ropana*.
2. Analyze the pharmacological and biological mechanisms of key Ayurvedic wound-healing interventions.
3. Correlate each step of the classical approach with the corresponding phases of modern wound healing at the molecular and cellular levels.
4. Discuss the clinical applicability and integrative potential of these principles, particularly in chronic and infected wounds.

II. AIM AND OBJECTIVES

2.1 Aim

To critically analyze the roles of *Vrana Shodhana* and *Vrana Ropana* in tissue repair by integrating classical Ayurvedic teachings with contemporary molecular and clinical understanding.

2.2 Objectives

- To elaborate the classical concepts of *Vrana*, its classification, and pathogenesis (*samprapti*).
- To delineate the therapeutic interventions and pharmacological actions of *Shodhana* and *Ropana* dravyas.
- To correlate Ayurvedic principles with the recognized phases of wound healing (hemostasis, inflammation, proliferation, remodeling).
- To discuss the relevance of these principles in managing chronic, infected, and diabetic wounds.
- To propose an integrative framework for combining modern and Ayurvedic wound care.

III. MATERIALS AND METHODS

- Type of Study: Conceptual and narrative review with critical analysis.
- Classical Sources: *Sushruta Samhita* (Sutra Sthana, Chikitsa Sthana) [1,2,3]; *Charaka Samhita* (Chikitsa Sthana) [4]; *Ashtanga Hridaya* (Sutra Sthana, Chikitsa Sthana) [5].
- Modern Sources: Standard textbooks of physiology and surgery [6,7]. peer-reviewed articles from PubMed, Scopus, and Google Scholar (2000–2025) on wound healing, inflammation, angiogenesis, and Ayurvedic pharmacology [8–15].
- Methodology: A comparative, side-by-side analysis of classical descriptions with modern scientific evidence was performed. Emphasis was placed on mechanistic correlations at the cellular and molecular levels.

IV. CONCEPT OF VRANA

4.1 Definition and Clinical Features

A *Vrana* is defined as a loss of tissue continuity with associated *Dosha* involvement, leading to structural and functional impairment [1,4]. Clinically, a *Vrana* presents with:

- *Shoola* (pain) – due to *Vata* aggravation
- *Srava* (exudate/discharge) – depending on *Dosha* dominance: serous (*Kapha*), purulent (*Pitta*), or hemorrhagic (*Rakta*)
- *Shopha* (edema/swelling) – inflammatory response
- *Varna* (color change) – redness (*Pitta*), pallor (*Vata*), or discoloration (*Kapha*)

- *Akriti* (shape and margins) – irregular, undermined, or healing [1,2].

4.2 Classification

A. Based on etiology [1]

- *Nija* (endogenous): Caused by internal *Dosha* imbalance (e.g., metabolic ulcers, diabetic wounds, abscesses from *Dosha* vitiation).
- *Agantuja* (exogenous): Resulting from external trauma – sharp instruments, blunt force, burns, animal bites, etc.

B. Based on wound status [2]

- *Shuddha Vrana* (clean wound): Healthy granulation tissue, minimal exudate, no foul odor, healing progressing.
- *Dushta Vrana* (infected/non-healing wound): Presence of slough, necrosis, purulent discharge, foul smell, surrounding cellulitis, and delayed or arrested healing [3].

C. Based on depth and tissues involved [1]

- *Twak gata* (skin-level)
- *Mamsa gata* (muscle-deep)
- *Sira/snayu/asthi gata* (involving blood vessels, ligaments, or bone) – prognosis worsens with depth.

4.3 Pathogenesis (*Samprapti*) of *Dushta Vrana*

The development of a *Dushta Vrana* follows a sequential pathology [2,3]:

1. Nidana sevana (causative factors): Diet, lifestyle, or trauma that vitiate *Vata*, *Pitta*, and/or *Kapha*.
2. Dosha prakopa (aggravation): Vitiated *Doshas* localize in a specific tissue region.
3. Dushya involvement (tissue damage): *Rakta* (blood), *Mamsa* (muscle), *Meda* (fat), etc., are affected.
4. Inflammation and suppuration: Aggravated *Pitta* and *Rakta* cause heat, redness, and pus formation (*puyotpatti*).
5. Tissue necrosis and chronicity: Aggravated *Vata* and *Kapha* lead to cold, indolent ulcers with poor granulation, foul odor, and delayed healing.

Classically, a *Dushta Vrana* is characterized by five features: *adura* (non-healing), *ati srava* (excessive discharge), *durgandhata* (foul smell), *vedana* (pain), and *kathinata* (induration) [3].

V. VRANA SHODHANA (WOUND PURIFICATION)

5.1 Definition and Scope

Vrana Shodhana refers to the process of removing vitiated *Doshas*, necrotic tissue (*kleda*, *puyasrava*), slough, and microbial load, thereby converting a *Dushta Vrana* into a *Shuddha Vrana* [1,3]. It is a necessary precondition for *Ropana*.

5.2 Classical Foundation

"दुष्टव्रणशोधनं कर्तव्यम्" (An unclean wound must be purified) [2].

"शोधनाद् व्रणः शुद्धताम् आपद्यते " (Purification brings cleanliness to the wound) [3].

5.3 Objectives of Shodhana

- Removal of necrotic tissue and slough (*ashuddha mamsa*)
- Reduction of microbial contamination and biofilm
- Control of excessive inflammation and exudation
- Restoration of healthy wound bed with granulation potential
- Preparation for subsequent *Ropana* therapy

5.4 Methods of Shodhana

A. Surgical methods (Shastra Karma) [1]

- Debridement (*Chhedana*, *Bhedana*, *Lekhana*): Sharp or surgical removal of non-viable tissue.
- Drainage (*Srava nirharana*): Incision and drainage of abscesses or purulent collections.

B. Para-surgical methods [3]

- *Kshara Karma*: Application of alkaline agents for chemical debridement (e.g., *Apamarga Kshara*).
- *Agni Karma*: Thermal cauterization to burn slough or control bleeding.

C. Non-invasive / topical methods [2,5]

- *Prakshalana* (washing): Irrigating the wound with herbal decoctions (*Kashaya*) – e.g., *Triphala*, *Nimba*, *Haridra*.
- *Parisheka* (continuous irrigation): Slow drip of medicated liquids.

- *Lepa* (paste application): Applying herbal pastes that absorb exudate and have antimicrobial action.

5.5 Shodhana Dravyas (Pharmacology)

Dravya	Botanical name	Key actions (Ayurvedic)	Modern evidence [9,10,11]
Nimba	*Azadirachta indica*	*Krimighna* (antimicrobial), *Kushtaghna*	Antibacterial, antifungal, anti-biofilm, immunomodulatory
Haridra	*Curcuma longa*	*Shothahara* (anti-inflammatory), *Vranashodhana*	Curcumin inhibits NF-κB, reduces TNF-α, IL-6; promotes wound contraction
Triphala	*Terminalia* spp.	*Raktashodhaka* (blood purifier), *Kashaya* (astringent)	Gallic acid, chebulagic acid – antimicrobial, antioxidant, free radical scavenging
Manjishtha	*Rubia cordifolia*	*Raktaprasadaka*	Enhances angiogenesis, reduces oxidative stress [12]

These agents act by: (i) reducing bacterial load, (ii) scavenging reactive oxygen species (ROS), (iii) modulating pro-inflammatory cytokines, and (iv) stimulating granulation.

5.6 Modern Correlation

Vrana Shodhana corresponds to the inflammatory phase of wound healing and the clinical concept of wound bed preparation [11,13]. Modern principles such as TIME (Tissue debridement, Infection/inflammation control, Moisture balance, Epithelialization edge advancement) are directly paralleled by *Shodhana* [8]. In diabetic or ischemic wounds where the inflammatory phase is dysregulated, aggressive *Shodhana* can restore the healing trajectory.

VI. VRANA ROPANA (WOUND HEALING AND TISSUE REGENERATION)

6.1 Definition and Scope

Vrana Ropana is the process of restoring tissue integrity through regeneration and repair after the wound has been adequately cleansed [1,3]. It includes granulation tissue formation (*mamsa rohana*), angiogenesis (*sira prarohana*), epithelialization (*twak prarohana*), and finally scar maturation.

6.2 Classical Foundation

"शुद्धे व्रणे रोपणं कुर्यात्" (Healing should be done after the wound is clean) [3].

"रोपणीयानि व्रणस्य मांस प्ररोहणार्थम्" (Ropana agents promote the regrowth of flesh) [2].

6.3 Objectives of Ropana

- Stimulate granulation tissue formation
- Promote angiogenesis to supply oxygen and nutrients
- Accelerate re-epithelialization
- Enhance collagen synthesis and maturation
- Minimize scar contracture and optimize cosmetic outcome

6.4 Methods of Ropana

A. Local Applications [1,2,5]

- *Taila* (medicated oils): *Jatyadi Taila*, *Tila Taila* base – provide a moist environment, deliver lipophilic actives.
- *Ghrita* (medicated ghee): *Shatadhouta Ghrita*, *Mahamarichyadi Ghrita* – promote granulation, reduce burning sensation.
- *Lepa* (herbal pastes): *Madhu* (honey) + *Yashtimadhu* (licorice) – widely used for their wound-healing properties.
- *Kalka* (fresh herbal paste): e.g., *Durva* (Cynodon dactylon), *Kamala* (Nelumbo).

B. Systemic Interventions [4,5]

- *Rasayana* (rejuvenation): *Guduchi* (Tinospora cordifolia), *Ashwagandha* (Withania somnifera) – enhance immunity, tissue regeneration.
- *Pathya* (dietary regulation): Protein-rich diet, iron, zinc, vitamin C – support collagen synthesis.
- *Dosha pacification*: Internal medicines to correct the underlying *Dosha* imbalance

(e.g., *Tikta* (bitter) and *Madhura* (sweet) formulations for *Pitta*-type wounds).

6.5 Ropana Dravyas (Pharmacology)

Dravya	Key classical use	Modern mechanism [10,11,12,13]
Jatyadi Taila	*Vrana Ropana* (all types of wounds)	Enhances fibroblast proliferation, collagen synthesis, and epithelialization; inhibits bacterial growth
Madhu (Honey)	*Shuddha Vrana Ropana*	Osmotic debridement, hydrogen peroxide release, anti-biofilm, promotes angiogenesis
Ghrita (Ghee)	*Pitta-rakta* wounds	Provides fatty acids, supports cell membrane integrity, anti-inflammatory
Yashtimadhu (Licorice)	*Vrana Ropana*, *Kantha* disorders	Glycyrrhizin – anti-inflammatory, promotes VEGF, accelerates re-epithelialization
Guggulu (Commiphora)	*Dushta Vrana*, healing	Promotes granulation, reduces post-healing fibrosis

The molecular pathways involved include upregulation of transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF), and basic fibroblast growth factor (bFGF); downregulation of matrix metalloproteinases (MMPs) in chronic wounds; and activation of keratinocyte migration [14,15].

6.6 Modern Correlation

Vrana Ropana corresponds to the proliferative and remodeling phases of wound healing [6,7]. Specifically:

- Granulation = *Mamsa rohana*
- Angiogenesis = *Sira prarohana*
- Re-epithelialization = *Twak prarohana*
- Collagen deposition and scar maturation = *Varna kara* (color restoration) and *Sthiratva* (stability).

VII. COMPARATIVE CORRELATION WITH MODERN WOUND HEALING PHASES

Ayurvedic Phase	Wound status	Modern phase	Key cellular events
Shodhana (initial)	*Dushta Vrana*	Inflammatory (and debridement)	Neutrophil/macrophage infiltration, ROS, cytokine release, debridement
Shodhana (ongoing)	*Shuddha Vrana*	Late inflammatory → resolution	Reduction of pro-inflammatory cytokines (TNF-α, IL-1β), MMP regulation
Ropana (early)	Granulating wound	Proliferative	Fibroblast proliferation, angiogenesis, granulation tissue, re-epithelialization
Ropana (late)	Epithelialized/scar	Remodeling	Collagen type III → I cross-linking, scar contraction, wound tensile strength

VIII. DISCUSSION

The principles of *Vrana Shodhana* and *Vrana Ropana* represent a remarkably sophisticated, stage-specific, and scientifically coherent system of wound management. When examined through the lens of modern molecular biology and clinical wound care, several key insights emerge.

8.1 Sequential logic and clinical necessity

Ayurveda's insistence on *Shodhana* before *Ropana* is not merely traditional – it is biologically essential. In chronic, non-healing wounds (e.g., diabetic foot ulcers, pressure ulcers), the healing process is stalled in the inflammatory phase due to persistent infection, high levels of pro-inflammatory cytokines (TNF-α, IL-1β), excessive matrix metalloproteinases (MMPs), and senescent fibroblasts [11,13]. Attempting to heal such a wound without first debriding necrotic tissue and controlling infection leads to failure. Modern "wound bed preparation" protocols (TIME framework) exactly mirror this sequence: Tissue debridement → Infection/inflammation control → Moisture balance → Epithelial edge advancement [8]. *Shodhana* covers the first two (debridement, infection/inflammation control), and *Ropana* addresses moisture and epithelialization.

Thus, the classical order is not arbitrary but grounded in pathophysiological reality. Clinical studies have shown that wounds treated with sequential *Shodhana* (e.g., *Nimba* decoction irrigation, *Triphala* wash) followed by *Ropana* (e.g., *Jatyadi Taila*) heal faster and with less scarring than those treated with only one of the steps [9,13].

8.2 Molecular mechanisms underlying *Shodhana* and *Ropana*

Modern pharmacological research has validated many of the classical claims:

- Antimicrobial and anti-biofilm activity: *Nimba* (neem) extracts have been shown to inhibit *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *E. coli*, including methicillin-resistant strains (MRSA) [10]. *Haridra* (curcumin) disrupts bacterial biofilms and reduces virulence factor expression. This directly supports *Shodhana*'s goal of eliminating *Krimi* (microbes) and *Puyasrava* (purulent discharge).
- Anti-inflammatory and antioxidant effects: Chronic wounds exhibit excessive ROS and inflammatory cytokines. Curcumin, *Triphala* (gallic acid), and *Manjishtha* have potent ROS-scavenging and NF-κB-inhibiting properties, thereby reducing tissue damage and promoting a switch to the proliferative phase [11,12].
- Angiogenesis and granulation: *Jatyadi Taila* and honey have been shown to upregulate VEGF and angiopoietin-1, leading to increased capillary density in the wound bed [13]. *Yashtimadhu* (glycyrrhizin) promotes keratinocyte migration via ERK1/2 pathway activation [14].
- Collagen synthesis and remodeling: *Ghrita* preparations provide essential fatty acids and fat-soluble vitamins (A, D, E, K) which serve as substrates for cell membrane synthesis. *Guggulu* has been shown to increase hydroxyproline content (a marker of collagen deposition) and reduce MMP-9 activity, thereby improving wound tensile strength [15].

8.3 Holistic perspective: beyond the local wound

Unlike conventional wound care, which often focuses solely on the wound site (e.g., dressings, topical antibiotics, growth factors), Ayurveda integrates systemic correction. This is particularly relevant for chronic wounds that arise from systemic diseases such as diabetes mellitus, chronic venous insufficiency, or malnutrition.

- Dosha correction: In diabetic ulcers, there is typically *Kapha-Meda* imbalance (obesity, hyperglycemia) along with *Vata-Pitta* aggravation (neuropathy, inflammation). Internal medicines like *Guduchi*, *Amalaki*, and *Haridra* improve insulin sensitivity, lower oxidative stress, and correct microangiopathy [4,5].
- Rasayana (immunomodulation and tissue regeneration): *Ashwagandha* (Withania somnifera) and *Guduchi* have been shown to enhance macrophage phagocytosis, increase lymphocyte proliferation, and promote healing in animal models of diabetes [16].
- Nutritional support (*Pathya*): Classical texts prescribe *Mamsa rasa* (meat soup), *Yavagu* (thin gruel), and specific vegetables to provide protein, vitamins (C, A), and minerals (zinc, iron) essential for collagen synthesis and immune function.

This integrated approach addresses both the local microenvironment and the host systemic state – a concept that modern wound care is increasingly embracing (e.g., nutritional support, glycemic control, offloading).

8.4 Clinical relevance in challenging wound types

Diabetic foot ulcers (DFU): DFU are characterized by neuropathy, ischemia, infection, and impaired healing. Conventional care includes debridement, offloading, antibiotics, and sometimes growth factors or skin substitutes. However, outcomes remain suboptimal, with high amputation rates. Several studies have reported that adjunctive use of *Jatyadi Taila* with standard care significantly reduces ulcer area, promotes granulation, and shortens healing time [9,17]. *Triphala* irrigation has been shown to reduce bacterial load and biofilm formation in diabetic wounds [18].

Infected and chronic venous ulcers: Venous ulcers often have a biofilm, excessive MMPs, and chronic inflammation. *Shodhana* with *Nimba* and *Haridra* re duces MMP-9 levels, while *Ropana* with honey

or *Ghrita* promotes granulation and epithelialization [13,19].

Post-operative wounds and burns: In clean, surgical wounds, *Ropana* alone (e.g., *Jatyadi Taila* or *Madhu*) has been shown to accelerate healing, reduce scar formation, and provide a moist wound environment superior to conventional gauze [9].

8.5 Integrative potential and research gaps

Integrating *Shodhana* and *Ropana* with modern wound care is both feasible and promising. For example:

- Mechanical debridement (modern) can be followed by herbal irrigation (*Triphala kashaya*) for antimicrobial and anti-biofilm action.
- Negative pressure wound therapy (NPWT) can be combined with topical *Jatyadi Taila* to enhance granulation.
- Bioengineered skin substitutes can be used together with systemic *Rasayana* to improve graft take.

However, major research gaps remain:

- Lack of large, double-blind, randomized controlled trials (RCTs) comparing standardized Ayurvedic protocols to conventional care.
- Variability in formulation preparation (e.g., *Jatyadi Taila* from different manufacturers) with no pharmacopoeial standardization.
- Limited mechanistic studies on many *Ropana* dravyas beyond in vitro or animal models.
- Need for validated outcome measures (wound area reduction, time to closure, quality of life) that are comparable across studies.

Future research should prioritize: (i) head-to-head RCTs with sham or conventional controls; (ii) identification of active molecular fractions; (iii) standardized manufacturing protocols; and (iv) cost-effectiveness analyses.

8.6 Strengths and limitations of this review

Strengths: Comprehensive and critical integration of classical Ayurvedic texts with modern molecular and clinical evidence; stage-wise correlation; emphasis on clinical applicability.

Limitations: Narrative review, not systematic; potential publication bias in cited modern studies; language limitations (classical verses in translation may lose nuance).

IX. CONCLUSION

Vrana Shodhana and *Vrana Ropana* constitute a comprehensive, stage-specific, and scientifically coherent framework for wound management. Their strong alignment with modern phases of healing – inflammation, proliferation, and remodeling – validated by molecular evidence (cytokine modulation, angiogenesis, collagen synthesis), demonstrates the depth and foresight of classical Ayurvedic knowledge. The sequential logic (cleanse first, then heal) is biologically essential, especially in chronic, infected, or diabetic wounds where the inflammatory phase is dysregulated.

Integrating these principles into contemporary clinical practice – using standardized *Shodhana* dravyas for debridement and infection control, and *Ropana* formulations for granulation and epithelialization – can significantly improve healing outcomes, reduce amputation rates, and lower healthcare costs. However, rigorous clinical trials and formulation standardization are urgently needed. Ayurvedic wound care is not an alternative but a complementary, evidence-ready addition to modern wound management.

X. FUTURE SCOPE

- Design and execute multi-center, randomized, double-blind, placebo-controlled trials of standardized *Shodhana* and *Ropana* protocols (e.g., *Triphala* irrigation followed by *Jatyadi Taila*) against conventional care in diabetic foot ulcers and venous ulcers.
- Isolate and characterize the active phytochemicals responsible for the wound-healing effects of *Jatyadi Taila*, *Madhu*, and *Yashtimadhu*.
- Develop validated pharmacopoeial standards (HPLC, GC-MS) for key Ayurvedic wound formulations.
- Investigate the molecular signaling pathways (e.g., TGF-β/Smad, VEGF, PI3K/Akt, Nrf2) modulated by *Ropana* dravyas using modern cell culture and animal models.
- Explore the synergy between *Rasayana* therapy and growth factor or stem cell therapies.

- Conduct health economic evaluations of integrated Ayurvedic-modern wound care pathways.

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